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by

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INTRODUCTION

In a letter dated June 1, 1982, Mr. D.C. MacKinnon of Sheritt Gordon Mines, Toronto, asked whether an evaluation of four vermiculite-containing samples from the Cargill Township phosphate area could be undertaken at CANMET. Mr. W.A. Gow, Director, Mineral Sciences Laboratories responded in a letter dated June 30, 1982, that this study could be done, on a full cost recovery basis, for $2200.00 with the work being limited to the four submitted samples. Work would include the following -

1. conduct a mineralogical examination to determine the presence of asbestos and asbestiform minerals;
2. prepare samples for exfoliation tests by stage crushing and screening;
3. determine the percentage of vermiculite in each sample;
4. prepare exfoliation tests to determine the degree of exfoliation;
5. determine bulk density of exfoliated vermiculite and loss of non-exfoliated material.

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SAMPLE PREPARATION AND DESCRIPTION

The four samples were identified as V-1, face; V-2, face; V-3, rocks; and coarse flakes, and are described in Table 1.

Table 1 - Sample description

Sample	Weight (g)	Description
V-1, face	5000	Mostly fine, minus 1 cm, brown, earthy material with a few rock-like pieces up to 10 cm size.
V-2, face	3500	Mostly brown to black, flake mica up to 3 cm size, with a few brown rock-like pieces up to 10 cm size.
V-3, rocks	7000	Brown, rock-like material up to 20 cm size with minor micaceous flakes.
Coarse flakes	2000	Coarse lumps or blocks of black micaceous flake material up to 10 cm in size.

Each sample was split into two equal portions, one being retained for reference, the other for further processing. Each representative half was stage-crushed by jaw crusher, following removal of the minus 12.5 mm (1/2 in.) fraction, to 12.5 mm. The removed minus 12.5 mm material was recombined with the jaw crusher product and the whole screened into 5 separate fractions for exfoliation tests. The gradings of these samples are shown in Table 2.

Table 2 - Gradings of crushed samples (wt %)

Sample	V-1	V-2	V-3	Coarse flakes
+4.75 mm (4 mesh)	28.1	47.9	52.2	72.8
-4.75 mm, +1.40 mm (14 mesh)	23.2	21.6	27.9	19.5
-1.40 mm, + 500 µm (35 mesh)	21.0	13.8	10.9	4.8
- 500 µm, + 150 µm (100 mesh)	17.3	10.9	5.9	1.9
- 150 µm	10.4	5.8	3.1	1.0
	100.0	100.0	100.0	100.0

Appropriate samples were prepared for examination by the Mineralogy Section.

EXFOLIATION TESTS

Sufficient material of each size fraction except the -150 µm was passed through a tube furnace to obtain enough exfoliated vermiculite to permit an approximation of the density of the exfoliated product to be made.

The electrically-heated tube furnace contained a stainless steel tube 50 mm in diameter by 1.2 m long. This was vibrated to move material through the furnace in about 30 sec. The temperature was maintained at 940 to 955°C which was adequate to exfoliate the vermiculite.

The exfoliated vermiculite in each fraction was separated from the non-vermiculite portion by a stream of air blown over the material. The weight and volume of the exfoliated vermiculite, and the weight of the non-vermiculite portions were used to determine the density and the percentage vermiculite in each fraction. Results are shown in Table 3. It should be noted that conditions of crushing and exfoliation were not necessarily those that would give optimum exfoliation and recovery of vermiculite.

Table 3 - Exfoliated vermiculite

Size fraction	Grading wt %	Vermiculite in fraction wt %	Vermiculite in sample wt %	Unit weight kg/m^3
Sample V-1				
+4.75 mm (4 mesh)	28.1	6.2	1.7	305
-4.75 mm, +1.40 mm (14 mesh)	23.2	10.5	2.4	255
-1.40 mm, + 500 µm (35 mesh)	21.0	21.7	4.6	240
- 500 µm, + 150 µm (100 mesh)	17.3	41.3	7.1	385
- 150 µm	10.4	-	-	-
	100.0		15.8	
Sample V-2				
+4.75 mm (4 mesh)	47.9	74.3	35.4	110
-4.75 mm, +1.40 mm (14 mesh)	21.6	72.4	15.6	160
-1.40 mm, + 500 µm (35 mesh)	13.8	69.9	9.6	225
- 500 µm, + 150 µm (100 mesh)	10.9	70.3	7.6	450
- 150 µm	5.8	-	-	-
	100.0		68.2	
Sample V-3				
+4.75 mm (4 mesh)	52.2	11.3	5.9	290
-4.75 mm, +1.40 mm (14 mesh)	27.9	8.0	2.2	335
-1.40 mm, + 500 µm (35 mesh)	10.9	11.5	1.3	480
- 500 µm, + 150 µm (100 mesh)	5.9	9.4	0.6	530
- 150 µm	3.1	-	-	-
	100.0		10.0	
Sample Coarse flakes				
+4.75 mm (4 mesh)	72.8	100	72.6	130
-4.75 mm, +1.40 mm (14 mesh)	19.5	100	19.5	175
-1.40 mm, + 500 µm (35 mesh)	4.8	100	4.8	255
- 500 µm, + 150 µm (100 mesh)	1.9	100	1.9	480
- 150 µm	1.0	-	-	-
	100.0		98.8	

In all samples, the plus 4.75 mm vermiculite was not well exfoliated, in part undoubtedly because the flakes were not well delaminated. In samples V-1, V-2 and V-3, the vermiculite in the finer fractions was well exfoliated. In the finer fractions of the coarse flake sample most of the vermiculite was not well exfoliated. Many of the particles were needle-shaped rather than the desirable square shape. These observations indicate that the coarse flakes sample may be composed, to a large degree, of partially-altered mica and, to a lesser degree, of true vermiculite.

MINERALOGY

Two fractions of each of three samples, V-1, V-2, V-3 were selected for mineralogical analysis by X-ray diffraction using a quadruple Guinier-de Wolff focussing camera. Comparison with diffraction patterns from reference material established that vermiculite, in the untreated material, is indicated by a diffuse diffraction line equivalent to an interplaner spacing of about 15 Å.

Results from the two selected fractions of V-1, V-2 and V-3 show that they represent, adequately, the qualitative mineralogical composition of the whole sample. They are summarized in Table 4 with the results of the analysis of one fraction from the fourth, coarse flake sample.

Table 4 - Mineralogy

Sample No.	Size fraction	Minerals identified		
		Major	Minor	Trace
V-1, face	-1.40 mm + 600 µm	vermiculite, magnetite amphibole, pyroxene	-	calcite, ilmenite
	- 150 µm	vermiculite, calcite amphibole, pyroxene	-	magnetite, dolomite ilmenite
V-2, face	-1.40 mm, + 600 µm	vermiculite, mica	amphinole ilmenite	pyroxene, calcite magnetite
	- 150 µm	vermiculite, calcite ilmenite	amphibole, magnetite	pyroxene
V-3, rocks	-1.40 mm, + 600 µm	pyroxene	-	amphibole, jarosite ilmenite
	- 150 µm	pyroxene	jarosite	amphibole
Coarse flake	- 150 µm	mica, ilmenite	-	vermiculite amphibole

No asbestos was identified in the fractions examined.

CONCLUSIONS

Samples V-1 and V-3 contained only about 16 and 10% vermiculite respectively, and the majority of the vermiculite was in the 150 to 500 µm size. The small size and the relatively low percentage of flake eliminate these samples from commercial consideration. The coarse flake sample, although of seemingly pure micaceous material, appears to be largely a partially altered mica. Sample V-2 contains sufficient vermiculite of a suitable size to have potential in loose insulation, and as concrete and plaster aggregates.